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Journal of Cleaner Production 14 (2006) 405–414
Journal of Cleaner Production
www.elsevier.com/locate/jclepro

Note from the field

The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita District

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Received 14 July 2003; received in revised form 18 January 2004; accepted 19 January 2004
Available online 26 April 2005

Abstract

This paper reports the findings of a study undertaken to assess the socio-economic and environmental impacts of mining in Geita District, Tanzania. In addition to sampling community perceptions of mining activities, the study prescribes interventions that can assist in mitigating the negative impacts of mining. Marked environmental and interrelated socio-economic improvements can be achieved within regional artisanal gold mines if the government provides technical support to local operators, regulations are improved, and illegal mining activity is reduced.

Keywords: Socio-economic; Mining activities; Local people; Gold mining; Geita District

1. Introduction

Mining is a major economic activity in many developing countries [1,2]. Operations, whether small- or large-scale, are inherently disruptive to the environment [3], producing enormous quantities of waste that can have deleterious impacts for decades [2]. The environmental deterioration caused by mining occurs mainly as a result of inappropriate and wasteful working practices and rehabilitation measures. Mining has a number of common stages or activities, each of which has potentially-adverse impacts on the natural environment, society and cultural heritage, the health and safety of mine workers, and communities based in close proximity to operations [4,5]. As indicated by Noronha [6] the social and environmental impacts are more pervasive in regions where operations are newly-established or are closing down. Several authors [1,7] have commented on the potentially-adverse impacts of mining, which include displacement of local people from ancestral lands, marginalization, and oppression of people belonging to lower economic classes.

Tanzania is endowed with abundant mineral resources of international value, including gold, diamonds, salt, gypsum, gemstones, iron ore, natural gas, phosphate, coal, nickel, cobalt and tanzanite. The country's major gold fields are located in Geita, Musoma, Tarime, Chunya and Mpanda [8]. Although records indicate that mineral exploration and exploitation in Tanzania began in the 1880s following the establishment of the German administration [9], there is evidence suggesting that local people, using traditional methods of mineral prospecting, produced minerals centuries before the establishment of the colonial administration [10–12]. Hilson [13] reports that as many as 40,000 years ago, regional hunter-gatherers exploited obsidian and chalcedony rock for stone implements and weapons, and used iron ore for painting.

Abbreviations: CRBEP, Columbia River Bioregional Education Project; GDP, Gross Domestic Product; HBS, Household Budget Survey; IDRC, International Development Research Centre; LVGF, Lake Victoria Gold Fields; MEM, Ministry of Energy and Minerals; NBS, National Bureau of Statistics; PRA, Participatory Rapid Appraisal; UNEP, United Nations Environmental Program; URT, United Republic of Tanzania.

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0959-6526/$ - see front matter
doi:10.1016/j.jclepro.2004.01.012

The government of Tanzania instituted a new Mining Act in April 1998 that is conducive to foreign investment [14]. Mineral production increased by 51% in 1991 and 24% in 1992, mainly in response to the implementation of the Trade Liberalisation Policy in 1985 and the enactment of the National Investment Act in 1990 [12]. Tanzania has a series of older mines, such as Williamson Diamond Mine at Mwadui and the Kiwira Coal Mine in Tukuyu, as well as a number of newer operations, most of which have been established in the Lake Victoria Gold Fields (LVGF).

As indicated in the Tanzania Economic Survey, industry liberalization has been a major reason behind marketed increases in national mineral production [3]. Notable achievements include increased gemstone and gold production, which, between 1984 and 1991, increased from 400 to 29,600 and 39,500 to 3,851,000 tons, respectively [10]. Currently, Tanzania ranks third in continental gold production behind South Africa and Ghana [15]. Rises in mineral production has increased the contribution of the mining sector to national Gross National Product (GDP), which rose from 1.1% in 1989 [16] to 2.3% in 2000 [14,17,18]. However, overall, mining contributes a relatively small share to national GDP, suggesting that the Tanzanian government, despite its successes in attracting foreign investment, has allowed incoming mining companies to export the bulk of extracted and processed product. In fact, findings by Tauli-Corpuz [1], Akabzaa [5], Darimani [19], Jones [20] and Awudi [21] confirm that mining has provided marginal contributions to the communities surrounding operations.

Although the exploitation of mineral resources is now considered to be one of the chief causes of pollution in Tanzania, there is growing realization that mining activities can be undertaken in a fashion whereby economic contributions are maximized, social conditions are improved, and damages to the environment are minimized. The majority of the country's mining ventures are involved in the extraction of gold and other gemstones in the Kahama and Geita Districts. Despite the widespread documentation of increased mineral production within these regions, minimal analysis has been undertaken to determine the impacts associated with the expansion of activities.

2. Methodology

2.1. Aims and objectives

In a case study of the Geita District, the present study sought to determine the severity of the Tanzanian mining industry's environmental and socio-economic impacts. The specific objectives of the study are as follows:

- To identify and assess socio-economic activities which are significantly influenced by mining activities.
- To examine local communities perceptions on how mining activities impact the environment.
- To suggest interventions that can assist in mitigating the negative impacts of mining.

This study was based upon the following hypotheses: 1) that mining activities have significant socio-economic impacts on livelihoods of local communities; 2) that regional activities also have significant impacts on the environment; and 3) the type and nature of mining activities have different impacts.

2.2. Description of the study area

Geita is one of the administrative districts in Mwanza region, covering 7825 km^2, of which 6775 km^2 is landmass and 1050 km^2 is water – mostly, Lake Victoria [22]. Geita District is located northeast of Sengerema District, northwest of Kagera Region, southeast of Kwimba District, and south of Shinyanga Region. It is situated on the shore of Lake Victoria, between 2° 28′–3° 28′ south and 32°–32° 45′ east. Administratively, Geita District is divided into seven separate divisions, and 27 wards with 163 villages [22]. Geita District is accessible via an all-season road, which originates from Mwanza Town through Sengerema District and connects to the Biharamulo District to the Republic of Rwanda. The District is in Tanzania.

2.3. Data collection and analysis

Data for the case study were obtained from both primary and secondary sources. Primary data were obtained using a combination of methods, including participatory rural appraisal (PRA) tools and techniques, participant observations, and informal and formal surveys. Pair-wise ranking was first performed to help identify problems caused by mining activities as experienced by the local people in the study area, and to rank socio-economic activities based upon their contribution to household livelihood. Frequencies, percentages and means are used in the discussion. Analysis of variance (ANOVA) and cross tabulations involving chi-square tests were used to test statistical differences in various variables between mining and non-mining communities.

3. Results and discussion

3.1. Socio-economic characteristic of respondents

Table 1 details the proportion of males and females interviewed during the survey. There was no significant

Table 1
Socio-economic characteristic of respondents in this survey

Variable	Community status		Total ($n = 148$)	χ^2-Value
	Mining community ($n = 74$)	Non-mining community ($n = 74$)		
Gender				0.157^{ns}
Male	62 (83.8)	55 (74.3)	117 (79.1)	
Female	12 (16.2)	19 (25.7)	31 (20.9)	
Household size				0.942^{ns}
1–3	12 (16.2)	13 (17.6)	25 (16.9)	
4–6	26 (35.1)	26 (35.1)	52 (31.1)	
7–9	23 (31.1)	20 (27.0)	43 (29.1)	
>9	13 (17.6)	15 (20.3)	28 (18.9)	

Source: Field survey (2002).
Figures in parentheses are percentages and those out of parentheses are frequencies.
ns = Non-significant at $P > 0.05$.

difference in gender within surveyed mining and non-mining communities ($p > 0.05$). Only 25% of the workers in mine camps were females (Table 2), likely because mining jobs are gender-oriented, demanding the services of more males than females. Mining and non-mining communities exhibited minimal difference in terms of average household size: the average household size was 6.6 and 6.5 people within the surveyed mining and non-mining communities, respectively (Appendix 1). According to the 2000/2001 Household Budget Survey (HBS) of Tanzania, the average household size on the mainland is 4.9 people [23]. Surveyed areas likely have comparatively higher household sizes because of the existence of the mining activities, which precipitate population growth through migration.

Within the surveyed area, respondents reported to be involved in diverse economic activities, including agriculture, mining, subsistence business activities, and livestock rearing (Table 3). Some 33.8% of respondents

Table 2
Characteristics of mine employees interviewed

Variable	Community status		Total ($n = 96$)	χ^2-Value
	Mining community ($n = 84$)	Non-mining community ($n = 12$)		
Age category (years)				0.027*
<18	12 (15.2)	–	12 (12.5)	
18–30	18 (22.8)	10 (58.8)	28 (29.2)	
31–43	30 (38.0)	4 (23.5)	34 (35.4)	
44–56	13 (16.5)	3 (17.6)	16 (16.7)	
>56	6 (7.6)	–	6 (6.3)	
Gender				0.050*
Male	63 (75.0)	12 (100.0)	75 (78.1)	
Female	21 (25.0)	–	21 (21.9)	

Source: Field survey (2002).
Figures in parentheses are percentages and those out of parentheses are frequencies.
*Significant at $p < 0.05$.

Table 3
Socio-economic activities of the respondents

Variable	Community status		Total ($n = 148$)	χ^2-Value
	Mining community ($n = 74$)	Non-mining community ($n = 74$)		
Main occupation				
Agriculture	35 (47.3)	50 (67.6)	85 (57.4)	0.013*
Mining	25 (33.8)	–	25 (16.9)	0.000***
Petty business	7 (9.5)	13 (17.6)	20 (13.5)	0.355^{ns}
Agriculture and mining	1 (1.4)	–	1 (0.7)	
Agriculture and livestock	2 (2.7)	8 (10.8)	10 (6.8)	0.049*
Charcoal dealer	–	2 (2.7)	2 (1.4)	
Government employee	3 (4.1)	–	3 (2.0)	
Construction works	–	1 (1.4)	1 (0.7)	
Agriculture and petty business	1 (1.4)	–	1 (0.7)	

Source: Field survey (2002).
Figures in parentheses are percentages and those out of parentheses are frequencies.
***Significant at $P < 0.001$, **Significant at $P < 0.01$, ns = Non-significant at $P > 0.05$.

in mining communities reported to be engaged in mining as a primary occupation. Large proportions of respondents (47.3% and 67.6% in mining and non-mining communities, respectively) were engaged in agriculture. Traditionally, local people made their living from agriculture, fishing, hunting and livestock management. Artisanal mining has a long history in the mineral-rich areas of Geita. As the industry developed, it became the main source of income, attracting not only locals but also individuals from other regions. Some local people are driven to mine because of poor crop harvests – themselves the product of unfavourable weather conditions – and/or to supplement household income following the end of the agricultural season. It was indicated that poor mining methods are the main reason behind unpredictable mineral recovery, which is why many locals have elected to take up agriculture as a profession. Pits and underground excavations, which are commonly associated with high risks and accidents, are also discouraging many people from participating in mining directly. Generally, it was found that mining was not the major economic activity of the local people in Geita District but rather a complimentary source of income (Tables 4 and 5).

In Geita District, the dominant indigenous tribe is the Sukuma group, which comprise mainly socio-cultural agro-pastoralists. The results in Table 3 indicate that 2.7% and 10.8% of respondents in mining and non-mining communities, respectively, are agro-pastoralists ($p < 0.05$). However, it was frequently observed that mine pits (Plate 1) contributed to an abandoning of

Table 4
Pair-wise ranking of socio-economic activities in mining communities

Socio-economic activities	1	2	3	4	5	6	7	Rank
1. Mining	X							2nd
2. Farming	1	X						3rd
3. Farming and livestock keeping	1	2	X					4th
4. Charcoaling	1	2	3	X				5th
5. Petty business	5	5	5	5	X			1st
6. Bicycle transport services	1	2	3	4	5	X		6th
7. Water selling	1	2	3	4	5	6	X	7th
Frequency	5	4	3	2	6	1	0	

Source: Field survey (2002).

Table 5
Pair-wise ranking of socio-economic activities in non-mining communities

Socio-economic activities	1	2	3	4	5	6	7	Rank
1. Farming and livestock keeping	X							2nd
2. Lumbering	1	X						3rd
3. Charcoaling	1	3	X					4th
4. Farming	4	4	4	X				5th
5. Selling food crops	1	5	5	4	X			1st
6. Bicycle transport services	6	6	6	4	5	X		6th
7. Employment in Geita Gold Mine	7	7	7	4	7	7	X	7th
Frequency	3	0	1	6	3	3	5	

Source: Field survey (2002).

agro-pastoral systems in mining communities, findings which suggest that mining activities have a negative socio-cultural impact on the livelihoods of local people.

3.2. Impact of mining on the livelihoods of local people

The evidence from Table 6 indicates that approximately 93% and 80% of respondents in mining and non-mining communities, respectively, benefit differently from the existence of mining activities ($p < 0.001$). Within mining areas, some 42% of respondents benefit from sources of mining employment; 20.3% from improved road networks, water and school construction; 11% from food crop sales; and 8.1% from subsistence (petty) business. It was found that only 8.1% of respondents in non-mining areas benefit from direct mining activities as a source of alternative employment, while 37.8% benefit indirectly from food crop sales, and 25.7% from subsistence (petty) business. The results indicate that mining activities have created a multitude of income opportunities for the inhabitants of Geita District.

There were significant differences in the benefits provided by the large-scale Geita Gold Mine Company to mining and non-mining area in terms of improved roads and water services ($p < 0.001$); specifically, non-mining communities appear to be more neglected than mining communities. The findings are supported by IDRC [24], which portrayed mining communities as the beneficiaries of a wide range of new services, including improved access to education and health services.

The presence of mining activities in Geita District has created market opportunities for local farmers. As indicated in Table 6, approximately 11% and 38% of respondents in mining and non-mining communities, respectively, secure markets for their agricultural crops

Plate 1. Abandoned inactive mine pits at Nyarugusu mining site. Source: Field survey (2002).

Table 6
Surveyed perspectives on household benefits from mining activities

Variable	Community status		Total ($n = 148$)	χ^2-Value
	Mining community ($n = 74$)	Non-mining community ($n = 74$)		
Type of benefits				
Selling food crops	8 (10.8)	28 (37.8)	36 (24.3)	0.000***
Employment	31 (41.9)	6 (8.1)	37 (25.0)	0.000***
Petty business	6 (8.1)	19 (25.7)	25 (16.9)	0.004**
Improved road network, water and school construction	15 (20.3)	–	15 (10.1)	0.000***
Employment and markets for crops	6 (8.1)	1 (1.4)	7 (4.7)	
No benefit	5 (6.8)	15 (20.3)	24 (16.2)	

Source: Field survey (2002).
Figures in parentheses are percentages and those out of parentheses are frequencies.
***Significant at $P < 0.001$.

through their mining activities. Within surveyed mining communities, the average annual income earned from agriculture was reported to be US$88.32, compared to US$358.89 in the non-mining areas surveyed (Appendix 2). The influx of newcomers in search of employment at mine sites has increased demand for goods, thus improving opportunities for local people to sell their food crops. The market for agricultural crops may also explain why 47.3% of respondents indicated having a dependency on agriculture, while only 34% of local people interviewed near to mine centres reported being engaged directly in mining activities as a major source of income. The findings imply that mining significantly contributes to the incomes of local people employed in agriculture by providing markets to their agricultural products.

3.3. Contribution of mining to local income

An analysis of variance (Appendix 2) on income from agriculture and mining indicated that in mining and non-mining communities, respectively, average household income from mining was US$361.47 and US$15.04, and US$88.32 and US$358.89 from agriculture. As shown in Table 7, a complementary relationship exists between agriculture and mining within the study areas. Approximately 66% and 3% of average household income in mining and non-mining communities, respectively, is derived from mining. On the other hand, agriculture contributes 16% and 75% to total household income in surveyed mining and non-mining regions, respectively. The results suggest that while local people employed in mining obtain direct income as mining wages, non-miners increase their income through different socio-economic activities, including sales from food crops and menial business activities. These results parallel those from other ASM regions, such as those within

Table 7
Contribution of economic activities to total household annual income

Source of income	Mining communities		Non-mining communities	
	Average income (US$)	%	Average income (US$)	%
Agriculture	88.31846	16.17	358.8947	74.99
Mining	361.4686	66.18	15.04335	3.14
Other activities	96.42673	17.65	104.6724	21.87
Total	546.21379	100	478.61045	100

Source: Field survey (2002).

Bolivia, where McMahon and Remy [25] report that wages earned by employees at mining operations are spent on goods and services produced by local people, which, in turn, increases the incomes of local populations. At the national level, figures indicate a contribution of less than 5% to total GDP of the country, meaning that, the industry has not yet significantly increased sustainable income since the enactment of the mineral policy.

3.4. Indigenous perceptions of the environmental impacts of mining

A pair-wise ranking of problems, which elicited local peoples' perceptions on the problems experienced in mining communities, indicates that the most pressing problems in mining regions are pollution of water sources from mercury and cyanide, dust, mine pits, cracking and the collapse of buildings (Table 8). According to the Nyakabale village executive officer, since the inauguration of the Geita Gold Mine near the village in June 2000, local people have reported approximately 52 cases of housing collapse resulting from mine-induced explosions.

Mineral extraction involves the excavation of underground pits and the destruction of rocks using explosives, which has caused regional land degradation. The number of pits in the small-scale mining areas lies between 100 and 1000, at shaft depths ranging between 10 and 100 m; both agricultural and grazing lands have been destroyed. In Mugusu village, there are some 800 mine pits, of which 230 remain active. Inactive pits visited in Mugusu and Nyarugusu had not yet been

Table 8
Problem ranking in mining communities

Mine problems	1	2	3	4	Rank
1. Collapsing of buildings	X				1st
2. Effects of mercury chemical	1	X			2nd
3. Abandoned pits	1	2	X		4th
4. Deforestation	1	2	4	X	3rd
Frequency	3	2	0	1	

Source: Field survey (2002).

recovered and protected by miners, thus resulting in honeycombed structures (Plate 1). Moreover, stockpiles of excavated materials were observed in mine camps. According to mineworkers, abandoned pits are not seen as a serious problem, although they have caused disturbances to livestock keepers and farmers in the mining areas. Unprotected mining pits may possibly account for the fewer respondents (2.7%) undertaking agriculture and livestock-management tasks in mining areas, compared to the 10.8% in surveyed non-mining areas (Table 3). At the local level, the uncontrolled digging and abandoning of pits has caused destruction of land beyond economic and technical reclamation. Mine pits not only make land unfavourable for agricultural activities following closure but also adversely impact livestock and wildlife resources, which, in turn, affects locals, who depend on power and animal manure. Within the agro-pastoral systems in the Iringa and Mbeya regions of Tanzania, livestock contributes directly to food production by providing manure (fertilizer and power), milk and meat [26].

Some of the typical environmental impacts caused by artisanal mining activities include diversion of rivers, water siltation, landscape degradation, deforestation, destruction of aquatic life habitat, and widespread mercury pollution. Since amalgamation is simple, inexpensive and does not require skilled labour, it is the gold concentration method mostly used by local miners. The process employs metallic mercury to trap fine gold from ore pulp. During the process, mercury is often discharged with contaminated tailings; the usual practice is to burn the amalgam in open fire. When this happens, mercury accumulates in the lungs and kidneys of miners. Metallic mercury discharged into the environment (air, water, tailings) can be transformed by biochemical processes into methylmercury, which is readily available and may be found at elevated concentrations in higher levels of the food chain, particularly in aquatic systems (i.e. it is biomagnified). Individuals reliant on fish may be particularly susceptible to exposure to accumulated dangerous levels of methylmercury. Cases of acute intoxication, muscular atrophy, seizures and mental disturbance are prominent. Methylmercury is easily transferred from women to the fetus, with effects ranging from sterility, spontaneous abortion, and from mild-to-severe neurological symptoms.

Open pit mining similar to the activities of the Geita Gold Mine potentially generates enormous quantities of waste for each gram of gold recovered: for every 5–8 g of gold recovered, there is a potential waste material produced, amounting to 1 ton of ore disposed into the environment. For example, in the United States gold mining industry, each ton of gold mined generates 3 million tons of waste [27]. The wastes contain toxic elements and minerals, which may interact with water to generate contaminated fluids that can pollute soils, rivers, and large water bodies like Lake Victoria. During heavy rains, fluids, which are highly alkaline often, contain various forms of cyanide, and depending on the waste source, may be a potential source of pollution to the Lake. Although tailings are often deposited in lined facilities, leaks are not uncommon.

Most of Lake Victoria Gold Fields contain sulphide minerals associated with gold. After gold extraction, the decomposition of sulphide minerals releases acid waters in the form of acid mine drainage. Such drainage, which is now common in the old Geita Mine (mined before independence in 1960s), can contaminate nearby streams and ground water for centuries after a mine has closed. The formation of acid mine drainage is accelerated by high rainfall and high temperatures, reminiscent of the climate of Geita. The acids tend to leach heavy elements in tailings and mine waste dumps to produce toxic solutions which comprise heavy metals.

Cyanide used by large-scale mines and mercury used by ASM can potentially cause deleterious impacts in the Geita District. When exposed to sunlight, some forms of cyanide break down and can be easily recovered and recycled, while others do not and may persist in the environment for decades. Once exposed to the open environment, mercury vaporizes to the atmosphere to contaminate the environment. This can pose a serious health threat to the communities surrounding mining regions. Tailings and mine wastes containing heavy metals and cyanides may negatively impact aquatic life even if water standards are closely followed and monitored. Because many metals bio-accumulate in humid environments, consumption of contaminated foodstuffs and fish can be harmful.

Cyanide and mercury leakage or spillage, and improper disposal of mine wastes, can be deadly to humans and can poison ground water, farming land and the resources in water bodies which the livelihood of the majority of Sukuma Tribe depend on for their survival. Since most of the water resources in mining areas are used as sources of drinking water for inhabitants and livestock, pollution of water sources by cyanide and mercury can be a burden to the women and children who collect it for the household and livestock in rural communities.

3.5. Social and cultural impacts of mining

In Geita District, mining has also had socio-cultural impacts. These include displacement and unemployment, child labour, accidents, and theft. The opening of the Geita Gold Mine has resulted in high influxes of migrants in search of jobs. This, in turn, has resulted in prostitution, increased incidences of banditry, changes to indigenous lifestyle, and increased competition among local residents for natural resources.

Mineral exploitation involves the appropriation of lands from indigenous people and massive displacement of settlements. In rural communities, locals depend on the land as a source of livelihood. According to the District mine engineer; some 1800 villagers were forcibly displaced in Mtakuja, Nyamalembo and Nyamange villages in Mtakuja Ward, following the establishment of the Geita Gold Mine. The displacement threatened peoples' livelihoods and has resulted in confrontation between the local people and staff at the Geita Gold Mine. An influx of foreign mining companies has made it even more difficult for locals to secure land. In the 1980s, the Tanzanian government amended mineral policies for the sole purpose of creating a favourable investment climate for foreign mining companies. As a result, several small-scale miners and farmers have lost their mine sites, agricultural and grazing lands. The long-term implications of such displacement include accelerated food insecurity to landless classes, increased poverty and intensified environmental degradation. Displacement has already caused conflicts between the local people and the mine operators. There have since been additional social conflicts between small-scale miners and the large-scale mining companies, as the (small-scale) miners have begun to find that areas previously open to prospecting and mining of gold is now under the control of a private foreign company. Mihayo [28], for example describes the nature of disputes that have occurred at the Kahama, Merelani and Mara mines. Profound conflict among mineral stakeholders suggests that there is a weak or inadequate enforcement of natural resources policies in Tanzania.

Table 2 presents the age categories of mineworkers in the households interviewed. Some 12.5% of the mineworkers interviewed were children aged 18 and below. Many children where small-scale operations dominated were seen either working independently or assisting their parents with activities such as gold panning or the haulage of crushed rocks without protective gears: activities which expose them to serious physical and health risks. According to District medical officers, the prolonged exposure of children to dust can cause silicosis and silico-tuberculosis. The tendency of children working in mining encourages truancy in school and increases the school dropout rate.

Environmental pollution is a major problem in the mining areas of Geita District. Continuous disposal of mine wastes contributes to air and water contamination, which are detrimental to human health, livestock and wildlife biodiversity, and have serious effects on the welfare of the mining communities, especially groups of women and children. The health and safety of miners and the nearby communities are at risk from a variety of factors, ranging from the inhalation of mercury fumes and dust, to water contamination and poor safety procedures. Unprotected pits, for instance, during the rainy seasons, form breeding grounds for disease vectors such as mosquitoes and housefly — the agents that spread malaria and water borne diseases. Table 9 indicates some of the common diseases mentioned in the study area. The dust pollution mainly originating from explosives in Nyakabale village has been reported by local people to increase the rate of female miscarriage and air borne infections. Migration of young ladies into mining centres in search of non-existent jobs according to District medical officer has increased prostitution and the spread of venereal diseases including HIV and AIDS in mining regions (Table 9).

Table 9
Surveyed responses on the impacts of mining on human health

Variable	Community status		Total ($n = 148$)	χ^2-Value
	Mining community ($n = 74$)	Non-mining community ($n = 74$)		
Common diseases				
STD/HIV	28 (37.8)	14 (18.9)	42 (28.4)	0.011*
Water borne	10 (13.5)	3 (4.1)	13 (8.8)	0.042*
Air borne	9 (12.2)	2 (2.7)	11 (7.4)	0.028*
Malaria	9 (12.2)	21 (28.4)	30 (20.3)	0.014*
Worms	1 (7.74)	8 (10.8)	9 (6.1)	0.733^{ns}
Bilharzias	3 (4.1)	6 (8.1)	9 (6.1)	0.302^{ns}

Source: Field survey (2002).
Figures in parentheses are percentages and those out of parentheses are frequencies.
*Significant at $P < 0.05$, ns = Non-significant at $P > 0.05$.

Mine accidents in the surveyed regions range from minor to major injuries, and are severest during the rainy seasons and gold rushes. Mine-related fatalities generally occur because locals have little training or access to sophisticated equipment. Collapsing of tunnels and the presence of poisonous gases underground is responsible for the majority of mine-related accidents in Tanzania. The impact of tunnel collapse and high incidences of mining accidents force miners to use a lot of timber during pit excavations underground, resulting in forest degradation and associated environmental destruction. Based on district statistics, on average, 11 people die from mine-related accidents each year.

In the mining communities surveyed, crop theft was identified as a growing problem. Results suggest that in Nyarugusu, the villages in which small-scale mining is a dominant economic activity, some 5.4% of respondents indicated that small-scale mining encourages crop theft (Table 10). Both local people and miners are allegedly involved in crop theft. The data indicate that widespread of economic hardship, induced by the uncertainty of finding minerals, leaves many miners without sufficient cash to acquire food supplies and other basic necessities, and therefore, they immerse themselves in thievery; the existence of markets for food crops in mining areas is additional incentive for locals to engage in crop theft. Hangi [29] testified that the high money

Table 10
Surveyed responses on other impacts of mining

Variable	Community status		Total ($n = 148$)	χ^2-Value
	Mining community ($n = 74$)	Non-mining community ($n = 74$)		
Impacts				
Deforestation	10 (13.5)	6 (8.1)	16 (13.8)	0.290^{ns}
Farm crop theft	4 (5.4)	–	4 (2.7)	0.043*
Displacement of people	15 (20.3)	3 (4.1)	18 (12.2)	0.003**
Injuries	6 (8.1)	1 (4.1)	7 (6.1)	0.302^{ns}
Deforestation and theft	11 (14.9)	5 (6.8)	16 (10.8)	0.112^{ns}
Reduced household labour	7 (9.5)	12 (16.2)	19 (12.8)	0.219^{ns}
Alcoholism, drug and prostitution	18 (24.3)	12 (16.2)	30 (20.3)	0.220^{ns}

Source: Field survey (2002).
Figures in parentheses are percentages and those out of parentheses are frequencies.
ns = Non-significant at $P > 0.05$.

circulation in mining areas creates pockets of inflation, and puts pressure on the prices of essential goods.

4. Recommendations and conclusions

Mining practices have already caused serious social and environmental impacts in some mining areas in Tanzania, including Geita District. These problems include land degradation, damage to water quality, pollution, and harm to livestock and wildlife biodiversity. Although there is growing awareness of the importance of sound environmental management amongst mining stakeholders and Government officials in Tanzania, mitigation strategies are possibly offset by conflicts of interest on both political and economic grounds at central and local levels. To address the impacts of mining:

- The government should aim at providing technical support to local mine stakeholders such as training in facilitation and management tasks to local stakeholders. New technology has to be developed that uses fewer chemicals during extraction and processing, and mine waste should be regulated and turned into a non-harmful form before it is discharged to waste ponds.
- It has to be mandatory for all mining activities taking place in Tanzania, at both a large- and small-scale, to submit environmental impact assessment reports before a license to mine or explore can be granted. Improved regulations and independent monitoring teams should be commissioned to intervene before environmental and social problems spiral out of control.
- Strategies to eliminate illegal mining and to promote other income-generating activities like agriculture and agro small-scale industries may reduce pressures on mining, thus helping to improve the social, economic and environment management of natural resources.

This paper has examined the socio-economic and associated environmental impacts of small-scale mining in Geita District, Tanzania. Despite not being a primary economic occupation for the majority of the region's local people, mining does nevertheless provide essential supplementary income. In terms of environmental impacts, the perception shared within local communities is that mining has caused land degradation. Mine pits have clearly prevented farmers from harvesting animal manures, and excessive vibrations caused by repeated explosions have resulted in the cracking and collapsing of buildings near to mine sites. Policy changes and global influences have increased large-scale mining activities in Tanzania, creating clashes of interest between foreign and local parties. The impact of these changes has restricted small-scale miners, who depend on gold rush conditions for subsistence, from advancing and improving their livelihoods.

Acknowledgements

The author wishes to express special thanks to Dr. Y.M. Ngaga of the Department of Forest Economics, Sokoine University of Agriculture and Morogoro Tanzania who supervised the research work. The author also acknowledges Dr. Gavin Hilson of the Imperial College of Science, Technology and Medicine, London and an anonymous reviewer for their constructive comments on an earlier version of the manuscript.

Appendix 1. Average household sizes of surveyed mining and non-mining communities

ANOVA: Single Factor

Summary

Groups	Count	Sum	Average	Variance
Column 1	74	477	6.445946	7.647723
Column 2	74	479	6.472973	9.129397

ANOVA

Source of variation	SS	df	MS	F	P-value	F crit
Between groups	0.027027	1	0.027027	0.003222	0.954813	3.905939
Within groups	1224.73	146	8.38856			
Total	1224.757	147				

Source: Field survey (2002).

Appendix 2. Variation in household income from agriculture and mining activities in surveyed mining and non-mining communities

Income from agriculture (US$)

ANOVA: Single Factor

Summary

Groups	Count	Sum	Average	Variance
Column 1	74	6535.566	88.31846	13,677.78
Column 2	74	26,558.21	358.8947	58,812.91

ANOVA

Source of variation	SS	df	MS	*F*	*P*-value	*F* crit
Between groups	2,708,825	1	2,708,825	74.73582	8.78E−15	3.905939
Within groups	5,291,820	146	36,245.34			
Total	8,000,646	147				

Source: Field survey (2002).

Income from mining activities

ANOVA: Single Factor

Summary

Groups	Count	Sum	Average	Variance
Column 1	74	26,748.68	361.4686	120,063.7
Column 2	74	1113.208	15.04335	3401.296

ANOVA

Source of variation	SS	df	MS	*F*	*P*-value	*F* crit
Between groups	4,440,388	1	4,440,388	71.92951	2.26E−14	3.905939
Within groups	9,012,944	146	61,732.49			
Total	13,453,332	147				

Source: Field survey (2002).

Income from other economic activities

ANOVA: Single Factor

Summary

Groups	Count	Sum	Average	Variance
Column 1	73	7039.151	96.42673	46,600.6
Column 2	74	7745.755	104.6724	25,515.09

ANOVA

Source of variation	SS	df	MS	*F*	*P*-value	*F* crit
Between groups	2498.536	1	2498.536	0.069432	0.792539	3.906393
Within groups	5,217,844	145	35,985.13			
Total	5,220,343	146				

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